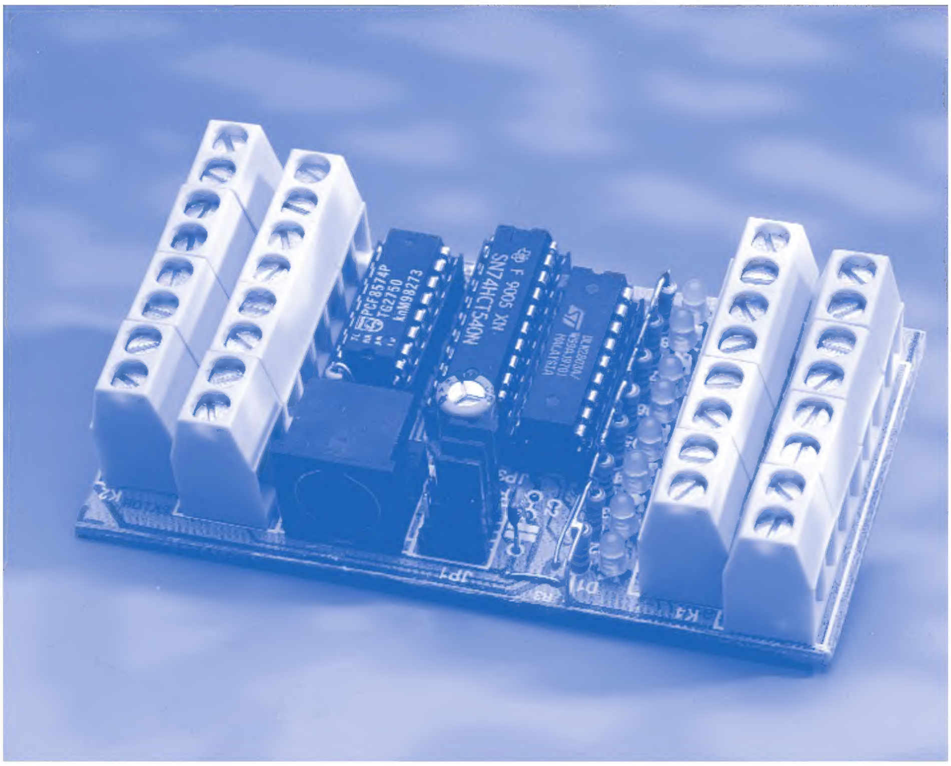
8-bit I/O port

control via the I^2C^{TM} interface

Design by H Böhling

I/O interfaces are published regularly in this magazine. Yet, each and every of them has its own special properties which makes it almost unique. The 8-bit port described in this article provides eight buffered outputs, eight inputs at TTL level, and communicates with the PC via the popular I2C interface. In spite of all these facilities, the circuit has been kept surprisingly compact.



Using an I^2C interface has a number of important advantages: all communications take place via a 2-wire arrangement; the interface is reliable, fairly fast, and well documented; and many I/O components are obtainable at reasonable prices. The only drawback is that the control computer or microcontroller needs an I^2C interface. Over the past few years, several I^2C interfaces have been published in this magazine: the latest one in this year's March issue. That interface was intended for connection to the printer port. It is supported by DDLs that may be used in a Windows environment. Great attention has also been paid to its use in microcontroller systems.

Up to 16 interfaces may be connected in parallel, which affords the user access to as many as 128 bidirectional I/O lines.

Circuit description

The circuit of the I/O interface shown in **Figure 1** is based on a Philips Type PCF8574(A) circuit that has proved very popular in several projects published in this magazine. More details of this IC are given in the box later on in the article.

The PCF8574 is linked to the outside world via a miniature DIN socket and via a connecting strip. The DIN connector carries the SCL and SDA control signals, the (optional) INT (interrupt) line, the supply voltage, and the earth line.

If several interfaces are used in parallel, the connecting strip becomes significant. Connectors K_2 and K_3 are so arranged that the interfaces may be interlinked simply by short lengths of circuit wire. Apart from the I^2C signals, the connecting strip also carries the supply line and the earth line. It also contains the common cathode connection for the freewheeling diodes in IC_3 (more about this later).

The base address of the PCF8574(A) may be adapted with jumpers Jp_1–Jp_3. If the PCF8574 is used, the base address is \$0100xxx (40 Hex), but if the PCF8574(a) is used, the base address is \$0111xxx (70 Hex). The base address is followed by the three bits set with the jumpers. Two base addresses and eight bit combinations give a total of 16 different addresses. This is why up to 16 modules

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I^2C is a trademark of Philips Communication

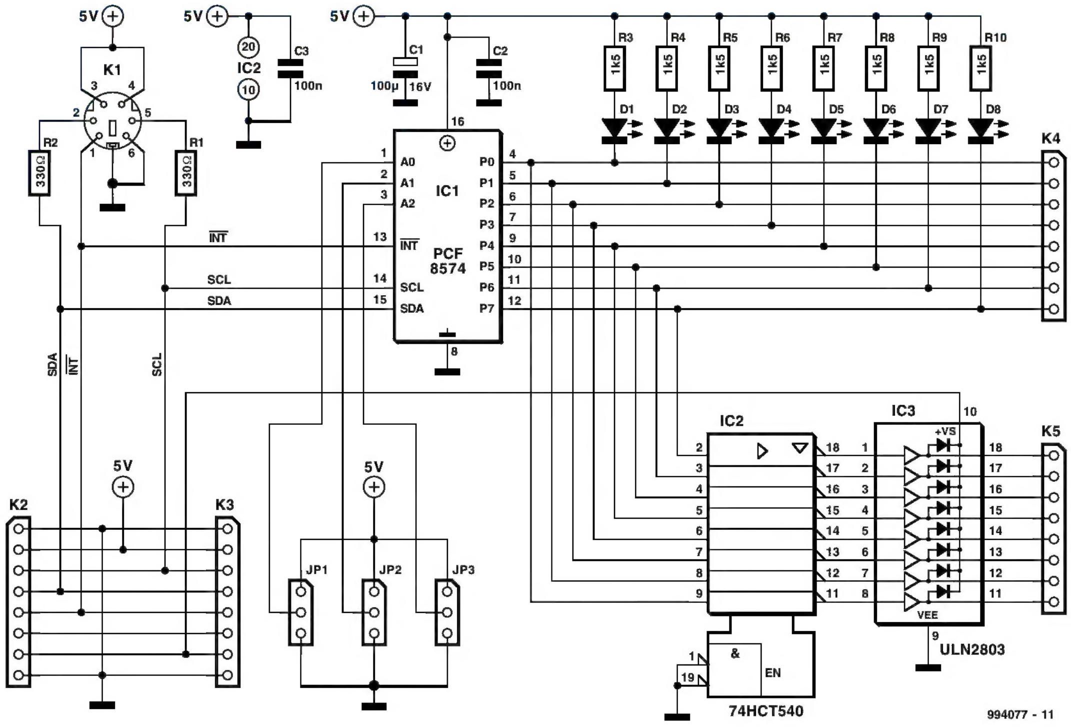

Figure 1. Circuit diagram of the I/O port which is intended to be controlled via an I2C interface.

may be connected to a single I^{2}C bus. The three variable bits are followed by a final bit, which determines the data direction (reading or writing).

The PCF8574(A) has eight bidirectional outputs: P_0–P_7. Each I/O line is provided with a pull-up resistor in series with an LED. When an I/O pin is arranged as an output, the associated LED shows the inverted output level. When the output is low, the associated LED is on, and when it is high, the LED is off.

When an input is not used, it can remain open thanks to the pull-up resistor.

An I/O pin is used as an output with the aid of

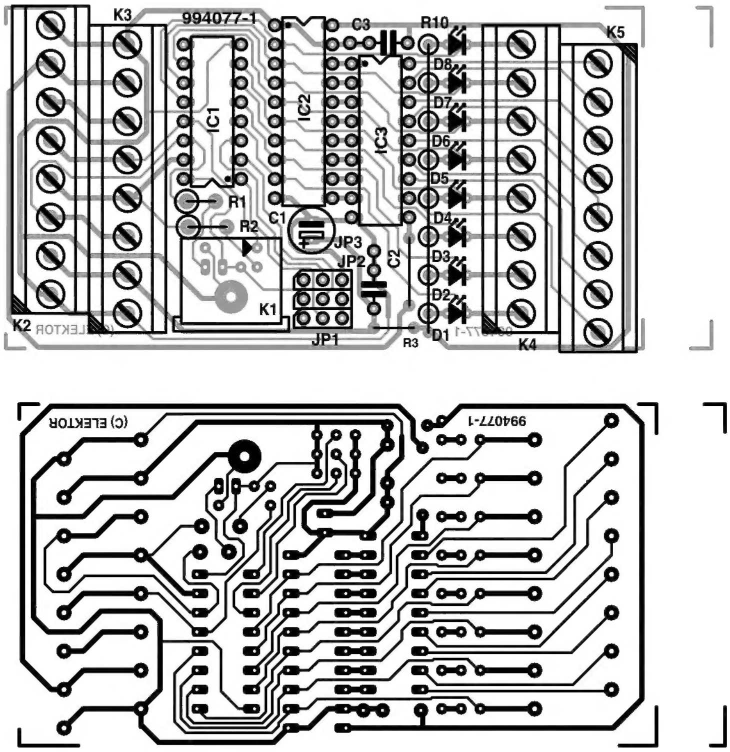

Figure 2. Printed-circuit board for the I/O port.

Parts list

Resistors:
R_1, R_2 = 330 Ω
R_3–R_{10} = 1.5 kΩ

Capacitors:
C_1 = 100 µF, 16 V, radial
C_2, C_3 = 0.1 µF

Semiconductors:
D_1–D_8 = LED, high efficiency

Integrated circuits:
IC_1 = PCF8574AP or PCF8574P
IC_2 = 74HCT540
IC_3 = ULN2803

Miscellaneous:
Jp_1–Jp_3 = 3-way PCB mount SIL socket with jump lead
K_1 = 6-way miniature DIN connector for PCB mounting
K_2–K_5 = 8-way PCB terminal strip, pitch 5 mm
Printed-circuit board Order No. 994077 (see Readers Services towards the end of this issue)

The PCF8574

The PCF8574 is a CMOS device that may be used to provide microcontrollers with additional I/O functions via an I2C bus. Its circuit diagram is shown in Figure 3. The device contains a quasi-bidirectional port and an I2C interface. A quasi-bidirectional port is one that may be used as input or output. Use as input requires that the port is made logic high via the software.

When the port is high, it may be used to register logic levels at the port connection. When the output is later read via a read command, it can be seen what logic level was put on to the input.

A port used as input may be reverted to use as an output by making it logic low, which requires an external current of at least 100 μA to flow from it to earth.

The power at the output ports is sufficient for driving LEDs direct—see Figure 3. The current drawn from a port cannot exceed 100 μA. The port can switch currents to earth of up to 25 mA.

There is a facility for generating an interrupt. When a port is arranged as an input, each change, negative or positive, will cause an interrupt. The interrupt is cancelled when its cause disappears, that is, when the port regains its original value, or after a read or write process has taken place from the port via the I2C interface.

After a hardware reset, the outputs of all ports are made high, which makes it possible for them to be used as input or as output.

Figures 4a and 4b show the signals that must be applied to the I2C bus to send data to, and receive data from, the microcontroller.

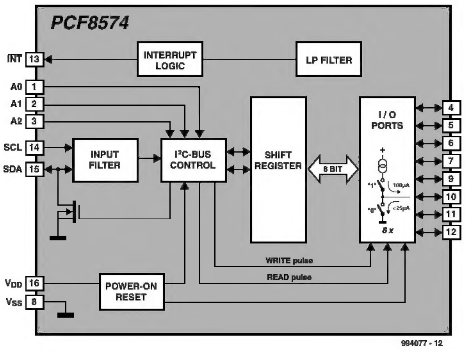

Figure 3. Internal circuit diagram of the PCF8574(A). The circuit was developed specially to make the control of I/O ports via an I²C interface possible.

IC_2 and IC_3. The former is a bus-driver that contains eight inverting buffers operating at TTL level. The buffers are used to control power driver IC_3. This circuit contains eight transistor-drivers with open-collector output. All outputs are provided with a freewheeling diode, the cathodes of which are all linked to pin 10.

Type ULN drivers like IC_3 are eminently suitable for switching small resistive and inductive loads (up to 50 V, 500 mA). This means that small lamps and relays can be driven directly. Bear in mind that the earth line of the supply used for the loads must be linked to the earth terminal (pins 1 and 8) of K_2 or K_3. Pin 1 is identified on the circuit diagram as well as on the board by a small triangle. When inductive loads are switched, the use of freewheeling diodes is essential. The cathodes of these diodes in IC_3 must be linked to the supply lines used. This means that the supply voltage must also be connected to pin 7 of K_2 and K_3.

Construction

The interface is readily built on the single-sided printed-circuit board shown in **Figure 2**. The electronic circuits are contained in the middle of the board, while, as stated earlier, the connections to the outside world are made via a 6-way DIN socket and 6-way PCB type terminal strips with screw or clamp terminals. Both types of terminal ensure a good, reliable electrical connection.

Since the terminals strips are positioned next to another, they must be mounted back-to-back.

When all elements have been mounted and their connections are soldered securely, check the finished board carefully. When all is found all right, choose the requisite address (es) with the aid of the jumpers, and connect them to a suitable interface.

The completed board fits nicely in a standard case that can be clipped on to a DIN rail.

There is, of course, software needed before the interface can be used. Normally, the interface is supported by a driver that can send the requisite data to, or retrieve from, the relevant address. This function is in most circumstances sufficient to obtain the desired results with the card.

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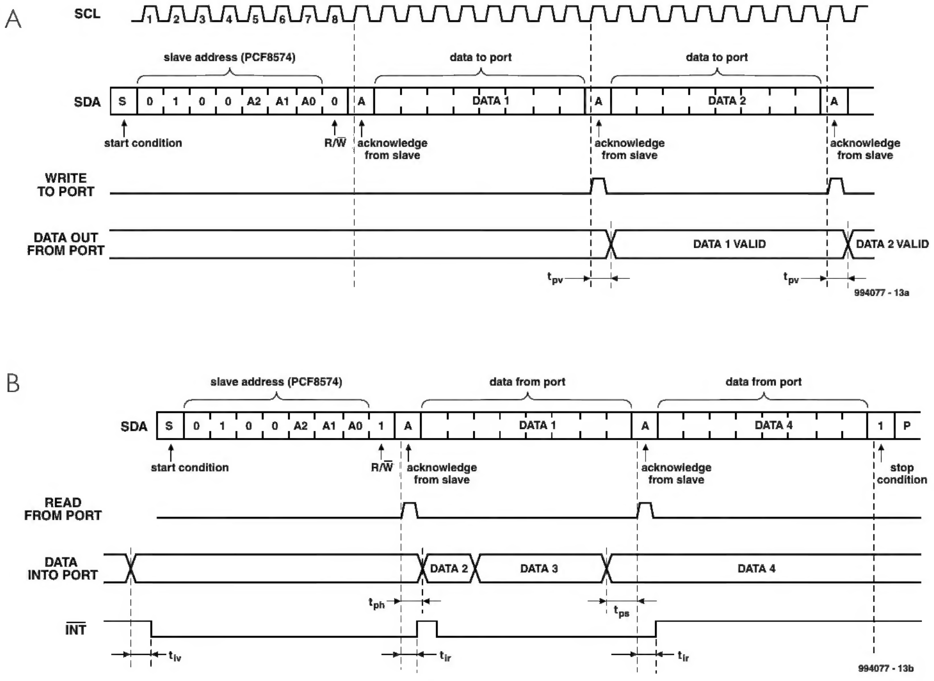

Figure 4. Timing diagram of a read and a write instruction executed by a PCF8574(A).